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ERASABLE MARKING COMPOSITION

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FIELD OF INVENTION

This invention relates generally to erasable marking compositions,
and more specifically, to water-based, erasable marking compositions
20 containing polyurethane.

BACKGROUND OF INVENTION

It is often desirable to produce ink images from a pen, marker, printer, or other application device which can be readily removed or erased. Typical
5 among these inks were compositions comprising a pigment and a liquid carrier or binder in which the pigment was dispersed. A common water-based erasable ink contained pigment in conjunction with styrene butadiene rubber (SBR) dispersions to provide erasability.

Some typical SBR based inks are disclosed in U.S Patent Nos.
10 5,389,717 to Santini et al., 5,599,853 to Loftin, 4,686,260 to Lindemann et al., and 4,596,846 to Bohne et al.

SBR based inks, however, had drawbacks. SBR based inks often became permanent over time as oxidation caused crosslinking to occur within the composition after it was applied to a substrate. It was observed
15 that as this crosslinking occurred over time, the erasability of the SBR based ink diminished. With enough time (on the order of weeks), the SBR based ink often became essentially unerasable.

Another potential drawback was that SBR based inks, when first applied, were actually too erasable - meaning they smeared and were easily
20 accidentally removed from the paper or surface to which they were applied. These inks also often formed a build-up on the writing nib (e.g. pen point) which usually resulted in an undesirable and unclean writing nib which would smear and apply ink unevenly.

One potential solution to the nib build-up problem was addressed through the use of expensive shaker balls and valve systems. These, although partially improving upon the nib build-up problem, were expensive and still did not solve the other problems.

5 Solutions were sought to the above problems and included the introduction of antioxidants into the ink composition to prevent oxidation, subsequent crosslinking, and the resultant undesirable impact on erasability. The introduction of these antioxidants extended the period of time one had to erase the ink, but even then often only out to about one month from the
10 time of application.

Attempts have been made to add glycerin to the SBR inks in order to prevent build-up of the ink on the writing nib. The introduction of glycerin was seen, however, to negatively impact the ink erasability and often made the erasure very dirty and left visually unpleasant smudges and smears.

15 Still other attempts have involved the use of certain inks in combination with specialized surfaces in order to achieve some degree of erasability. Such combinations are disclosed in, for example, U.S. Patent Nos. 5,217,255 to Lin et al., 4,940,628 to Lin et al., and 4,988,123 to Lin et al. These patents all require that the inks disclosed as erasable be used with
20 certain writing surfaces so as to be erasable. U.S. Patent No. 5,217,255, for example, teaches that the ink, in order to be satisfactorily erasable, be applied to a surface having an average pore diameter of between about 0.05 and 1.0 microns. Where the substrate does not have such an average pore diameter, it can be treated in order to achieve that range of porosity. Thus,

these patents teach ink/substrate systems which provide a degree of erasability.

The drawbacks discussed above suggest the need for a water-based composition that flows well through the writing nib (in the case where the composition is to be used in a pen or marker), does not easily smudge, but which is easily and effectively erased from any surface to which it is applied. Another desirable aspect to such an improved composition would be the length of time it remains easily and effectively erasable after it is initially applied.

SUMMARY OF INVENTION

The present invention provides a water-based, erasable marking composition comprising water, pigment, glycerin, and polyurethane. The composition may optionally include a surfactant. The ink composition of the present invention is a water-based ink composition that flows well through the writing nib (in the case where the composition is to be used in a pen or marker), does not easily smudge, is easily and effectively erased from the surface to which it is applied, and remains easily and effectively erasable from the surface to which it is applied for an indefinite length of time after it is initially applied to that surface. Also included in the present invention is an application instrument that uses the erasable composition of the present invention.

The water-based, erasable marking composition comprises 1 - 86% by weight water, 0.3 - 38% by weight pigment, 13 - 45% by weight

polyurethane, and 0 - 85% by weight glycerin, wherein the polyurethane has a viscosity which increases by at least a factor of 10 when the polyurethane is in an aqueous dispersion which is dried from a 30% dispersion of polyurethane in water to a 65% polyurethane dispersion in water. The composition optionally includes surfactants and anti-microbial preservatives. The preferred surfactant is a fluorosurfactant.

A more preferred embodiment comprises 13 - 69% by weight water, 5 - 15% by weight glycerin, 0.3 - 6% by weight pigment, and 26 - 42.5% by weight polyurethane, where the polyurethane is one which has a viscosity that increases by at least a factor of 10 when the polyurethane is in an aqueous dispersion which is dried from a 30% dispersion of polyurethane in water to a 65% polyurethane dispersion in water.

The most preferred embodiment comprises 52% by weight water, 9% by weight glycerin, 4% by weight pigment, and 35% by weight polyurethane, where the polyurethane is one which has a viscosity that increases by at least a factor of 10 when the polyurethane is in an aqueous dispersion which is dried from a 30% dispersion of polyurethane in water to a 65% polyurethane dispersion in water.

The invention also includes an application instrument comprising an outer body, an applicator, a reservoir included within the outer body and in fluid communication with the applicator, and a water-based, erasable marking composition within the reservoir. The water-based, erasable marking composition is that disclosed herein.

BRIEF DESCRIPTION OF THE DRAWING

The single FIGURE of the drawing is a graph comparing viscosity to percent solids for different polyurethanes tested in the development of the present invention.

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DETAILED DESCRIPTION OF INVENTION

The present invention provides an erasable composition, typically for use as an ink in a pen or marker (but having other applications, such as for use as a paint or in a printer cartridge), comprising an aqueous dispersion of a polyurethane elastomer and colorant. More specifically, the present invention provides a water-based, erasable marking composition comprising water, pigment, glycerin, and polyurethane. The polyurethanes used in the present invention are those which have a viscosity that increases by at least a factor of 10 when the polyurethane is in an aqueous dispersion which is dried from a 30% dispersion of polyurethane in water to a 65% polyurethane dispersion in water.

The water-based, erasable marking composition comprises 1 - 86% by weight water, 0.3 - 38% by weight pigment, 13 - 45% by weight polyurethane, and 0 - 85% by weight glycerin. The composition may optionally include a surfactant to aid in flowability. The preferred surfactant is a fluorosurfactant. The composition may also optionally include anti-microbial preservatives.

It is believed that the composition of the present invention forms a film on a suitable surface (such as a writing surface or substrate) to which it is applied (e.g. paper or whiteboard) that is strongly cohesive and minimally adhesive. The difference between cohesive and adhesive is understood by one skilled in the art. Generally, however, the more the composition adheres to the surface to which it is applied, the less easily that composition can be erased. In the case of the present invention, when the composition is erased, the film is removed in large sections because of the cohesive nature of the polyurethane within the film. This phenomenon produces a clean erasure.

It should be noted that for purposes of this disclosure, the word “erase” has its normal meaning. This would include the use of a piece of rubber, such as a pencil eraser, to rub the composition after it is applied to a surface, such as a piece of paper.

Although benefiting from the forming of the polyurethane film and the resultant cohesive properties associated with that film, the composition of the present invention also is more adhesive than traditional SBR-based inks. The presence of some adhesive qualities in the composition of the present invention decreases accidental removal and smudging when the composition is first applied.

This cohesive nature of the composition of the present invention, coupled with its display of suitable adhesiveness, means it can be applied cleanly and evenly, yet stay erasable for an indefinite period of time after it has been applied to a surface. Thus, although many SBR based inks become

permanent after crosslinking occurs (a matter of only days or even hours), the composition of the present invention stays erasable indefinitely.

An optional element of the composition according to the present invention is a surfactant. The addition of a surfactant aids in the wetting of the applicator (whether it be a pen tip such as a ballpoint nib or felt tip nib, or a paint brush, or any number of other applicators). By wetting, it is meant that the composition will attach to the surface of the applicator, be it bristles of a brush, a metal ball, or polyester fibers. Good wetability means the composition spreads on the applicator and can be easily delivered to the surface to which the user desires to apply the composition. If the applicator is not adequately wetted, the composition will not flow evenly onto the surface. A preferred surfactant is a fluorosurfactant, and the preferred fluorosurfactants are disclosed below in the several examples.

It should be noted that too much surfactant may affect the erasability of the composition. If too much surfactant is added, the composition can soak into the surface (in the case, for example, where porous paper is the surface to which the composition is applied) and become more difficult to erase. The inventors have disclosed herein the range of acceptable surfactant content to balance the need to wet the applicator against the detrimental decrease in erasability. A preferred amount of fluorosurfactant is from 0 - 1% by weight, and a more preferred amount is from 0.002 - 0.375% by weight.

Typically, the viscosity of the composition of the present invention is less than 20 centipoise when the composition is used as an ink. Higher

viscosities are preferred where appropriate, such as when the composition is used as a paint.

Tap water may be used as the source of water added to the composition. Deionized water is preferred in most cases, however, because
5 with increased presence of ions in the composition comes a decrease in stability. Moreover, ions can disrupt the dispersion of the pigment within the composition, leading to a loss of good dispersion and uneven color distribution within the composition, among other problems.

The erasability of the composition of the present invention depends
10 upon both the exact make-up of the composition used and the surface to which it is applied. Where lower amounts of polyurethane are present, erasability is not as good as where higher amounts are used. The surface to which the composition is applied, however, also affects the erasability. The acceptable ranges for the components of the present invention were
15 calculated based on a minimum acceptable erasability of 50% on typical types of paper. That is to say, where at least 50% of the applied mark is erased, the composition is considered erasable. Of course, the closer one gets to 100%, the more erasable the composition. As stated above, erasability depends on both the composition make up itself, and also the
20 surface to which it is applied.

Tests were conducted to find the acceptable ranges of components for the compositions according to the invention. For each composition, the percent erasability was determined. The percent erasability was defined
25 using the L value for the plain paper, the mark itself, and the erased mark, where the erasure was made using a typical eraser applied by hand to the

mark. The L value is defined as the “whiteness” or ‘lightness” in accordance with a standard developed by the Commission Internationale de L’Éclairage (CIE) to measure whiteness. It is a part of the CIE’s L*A*B* standard, and is well known to those skilled in the art. In this case, a
5 spectrophotometer was used, such as the one sold by Foresight Enterprises, Inc. of Grand Rapids, Michigan, under the name, X-RITE.

The percent erasability is defined as:

$$\% \text{ erasability} = (L_{\text{mark}} - L_{\text{erased mark}}) / L_{\text{mark}} \times 100\%.$$

10 This number can also be thought of as the percent change in L value between the mark and the erased mark, where the percent change in L value between the mark and the erased mark is the erasability.

15 Table 1 sets forth values for % erasability as defined above for the most preferred composition of the present invention for three different types of paper. The formulations used for each color are provided below in Tables 4 - 11. The three types of paper tested were: #1 Watermarked White, 20 lb Hammermill Bond Paper (bond paper); GreenCycle Ampad Wide-Ruled White (tablet paper); and Georgia-Pacific Spectrum DP Paper (copier paper).

TABLE 1

Ink Color	Bond Paper	College – Ruled Tablet Paper	Copier Paper
Black	88.8%	91.5%	84.7%
Violet	90.6%	93.6%	97.2%
Blue	88.4%	93.6%	88.5%
Green	91.3%	95.1%	90.2%
Red	91.3%	93.2%	88.4%
Orange	91.0%	95.3%	88.4%
Yellow	88.3%	92.2%	84.0%
Brown	90.5%	94.1%	89.6%

Additional experimentation was performed in order to ascertain the advantages of the inks of the present invention. Several ink formulations, including the inks of U.S. Patent No. 5,217,255 to Lin et al., as well as modifications thereof, were tested and compared to the inks of the current invention. When the ink formulation of Example 2 of U.S. Patent No. 5,217,255 was generated, it was discovered that it would not flow through a typical marker tip. Consequently, the inks were applied to the papers tested via a drawdown bar (3 mil) which delivered a three thousandths of an inch thick layer of ink onto each paper type.

Comparative Example 1

The first comparative ink composition tested comprised 60.8% by weight polymeric film-forming material, namely, styrene-butadiene latex, supplied by Goodyear Tire and Rubber Company, 2.0% by weight potassium oleate, 0.2% by weight benzotriazole, 5.0% by weight glycerine, 5.0% by weight ethylene glycol, 1.5% by weight pigment (Colanyl Blue A2R, sold by American Hoechst), and 25.92% by weight water. This is essentially Example 2 from U.S. Patent No. 5,217,255 to Lin et al. The results of % erasability testing (as defined above) are provided in Table 2.

Comparative Example 2

The second comparative ink composition tested comprised 54.5% by weight water, 9% by weight glycerin, 1.5% by weight pigment, and 35% by weight polyurethane. This composition is essentially the preferred composition of the present invention, with the exception that only 1.5% by weight pigment was used, as in Comparative Example 1 (still Colanyl Blue). The results of % erasability testing (as defined above) are provided in Table 2.

Comparative Example 3

The third comparative ink composition tested was comprised of the same materials and amounts as recited in Comparative Example 2, except that the pigment used was a blue pigment, such as the one provided commercially by Hoechst Aktiengesellschaft under the name, HOSTAFINE. The results of % erasability testing (as defined above) are provided in Table 2.

Comparative Example 4

The fourth comparative ink composition tested comprised 45% by weight polymeric film-forming material, namely, styrene-butadiene latex, supplied by Goodyear Tire and Rubber Company, 2.0% by weight potassium oleate, 0.2% by weight benzotriazole, 5.0% by weight glycerine, 5.0% by weight ethylene glycol, 1.5% by weight pigment (Colanyl Blue A2R, sold by American Hoechst), and 41.3% by weight water. This composition is essentially the same as that of Comparative Example 1, except for less polymeric film-forming material, and more water. The results of % erasability testing (as defined above) are provided in Table 2.

TABLE 2

Comparative Example	Bond Paper	College – Ruled Tablet Paper	Copier Paper
1	92.9%	76.2%	88.2%
2	92.3%	93.3%	90.4%

3	93.3%	93.0%	90.2%
4	69.7%	61.8%	57.2%

As can be seen through an examination of the data presented in Table 2, the inks of Comparative Examples 2 and 3 (essentially the compositions according to the present invention) produced superior results in generally all cases when compared to the inks of examples 1 and 4 (compositions according to the prior art). Indeed, the best inks were seen in Comparative Examples 2 and 3, which are essentially the inks of the present invention with the exception of slightly less pigment. The only difference between Comparative Examples 2 and 3 was that different pigments were used.

The composition of the present invention also works, however, for compositions different from the preferred composition. As addressed above, the acceptable ranges for the components of the present invention were calculated based on a minimum acceptable erasability of 50%. That is to say, where at least 50% of the applied mark is erased, the composition is considered erasable. Extending this definition to an analysis utilizing ΔL values, it can be seen that where the L value decreases by at least 50% when a mark is erased, that mark is considered erasable.

Table 3 presents data showing L values for three different black compositions, both before and after each mark is erased. Table 3 also shows the calculated % erasability for the black mark on three different types of surfaces – three different types of paper. For each type of paper, the paper itself was defined to have an L value of zero.

TABLE 3

	L value of mark	L value of erased mark	% change in L value ($L_{\text{mark}} - L_{\text{erased mark}} / L_{\text{mark}}$) (Erasability)
Black #1 on Bond Paper: 3% pigment 5% polyurethane 83% DI water 9% glycerin	-41.91	-22.86	45%
Black #2 on college-ruled notebook paper: 3% pigment 12.5% polyurethane 75.5% DI water 9% glycerin	-41.46	-18.68	55%
Black #3 on copier paper: 3% pigment 6% polyurethane 82% DI water 9% glycerin	-39.01	-19.24	51%

As can be seen from above, depending upon the surface to which the composition is applied, the polyurethane content may or may not be enough to insure good erasability. Thus, the minimum amount of polyurethane required was determined from an examination of the most porous paper – the college-ruled tablet paper. This amount of polyurethane will provide that the ink of the present invention will show good erasability no matter what type of paper is used.

A preferred composition according to the present invention comprises 13 - 69% by weight water, 5 - 15% by weight glycerin, 0.3 - 6% by weight pigment, and 26 - 42.5% by weight polyurethane. Although preferred where wetability is a problem, a surfactant is not always required to achieve
5 good application of the composition of the present invention.

PREFERRED POLYURETHANES

Not all polyurethanes work as well as others in the present invention. The inventors have determined that some polyurethanes, having particular
10 physical characteristics, provide a superior ink composition as compared to polyurethanes which do not have the particular characteristics. Specifically, polyurethanes which work best are those which have a viscosity that increases to at least 10 times an initial value at a 30% dispersion of the polyurethane in water after the 30% dispersion is dried to a 65%
15 polyurethane dispersion in water.

The single FIGURE of the drawing illustrates a graph produced from empirical data on various polyurethanes available commercially. Polyurethanes tested included Sancure 2104, Dispercoll U54, Dispercoll U53, Macekote 5574, and UR-CRYL U-4000. In each case, an aqueous
20 dispersion was tested. The viscosity of the dispersion increased as the solvent evaporated. Typically, and as can be seen by the graph of the drawing which shows viscosity as a function of percent solids (polyurethane solids), the viscosity increased gradually until a certain non-volatile (i.e.

solids) content is reached, at which point the viscosity increases swiftly. This phenomena is what determines the “gel point.”

In order to determine the gel point for each dispersion, viscosity was measured as the dispersion dried. The drying rate for the experimentation
5 was determined by drawing down a 6 mil wet film of each dispersion on glass and recording the weight as drying progressed. The measurements were carried out under constant ambient conditions of 23°C and 50% relative humidity. Viscosity as a function of solids was determined by placing 400 g of each dispersion in a 600 ml beaker and gradually heating to
10 about 90°C. Twenty-five (25) ml samples were collected periodically and transferred to sealed jars. Non-volatile content of the samples was measured by drying at 110°C for 1 hour. The viscosity of each sample was measured.

The graph of the drawing was then generated to show the relationship
15 between viscosity and percent solids. As can be seen from the plot, all polyurethanes tested, except the UR-CRYL U-4000 polyurethane, had noticeable upward slopes prior to the dispersion reaching 65 wt% solids. In some cases, the quick rise in viscosity was seen at relatively low solvent evaporation, such as the Sancure 2104 sample, where viscosity spiked at
20 only about 36% solids. Other samples, however, required the removal of more water before the spike was seen. Still other samples, such as the UR-CRYL U-4000, did not see its viscosity rise at all under 65% solids.

For each sample, an ink in accordance with the present invention was developed and tested for erasability as described above. It was seen that
25 certain polyurethanes produced inks with superior erasability over other

polyurethanes. Specifically, the ink produced with UR-CRYL U-4000 did not erase as well as inks made with the other polyurethanes tested as noted above.

From the experimented observations, it is surmised that polyurethanes which exhibit particular viscosity values relative to their dispersions' solids concentration produce inks with superior erasability. More specifically, and as seen in the graph, superior inks are produced using polyurethanes which exhibit a viscosity increase of at least 10 times its initial value when dried from a 30% dispersion in water to a 65% polyurethane dispersion in water. In other words, superior erasable inks are produced when the polyurethane is one which has a viscosity that increases by at least a factor of 10 when the polyurethane is in an aqueous dispersion which is dried from a 30% dispersion of polyurethane in water to a 65% polyurethane dispersion in water.

The following tables illustrate a specific embodiment of the present invention for eight different colored ink compositions. Values given are in weight percent of the particular component added to the system. It should be noted, however, that in some cases, the total amount of a particular component in the system may be slightly higher or lower than the amount shown for each component in the table. For example, because there is some water present in the pigment added, the pigment addition will add some water to the overall system. Particular specifications for each of the components are presented below in Tables 4 - 11, and will allow one skilled in the art to calculate the exact compositional makeup.

TABLE 4: BLACK

Water	51.78
Polyurethane resin	35.00
Glycerin	9.00
FC-120	0.08
Hostafine Black T (Pigment)	3.75
Proxel BZ	0.39
TOTAL	100.00

TABLE 5: VIOLET

Water	51.77
Polyurethane resin	35.00
Glycerin	9.00
FC-120	0.08
Hostatine Rubine	3.28
Hostafine Blue B2G	0.48
Proxel BZ	0.39
TOTAL	100.00

TABLE 6: BLUE

Water	51.77
Polyurethane resin	35.00
Glycerin	9.00
FC-120	0.08
Hostafine Rubine	0.48
Hostafine Blue B2G	3.28
Proxel BZ	0.39
TOTAL	100.00

TABLE 7: GREEN

Water	51.78
Polyurethane resin	35.00
Glycerin	9.00
FC-120	0.08
Hostafine Yellow Green	0.94

Green GN	2.81
Proxel BZ	0.39
TOTAL	100.00

TABLE 8: RED

Water	51.78
Polyurethane resin	35.00
Glycerin	9.00
FC-120	0.08
Hostafine Rubine F6B	2.81
Hostafine Yellow Hr	0.94
Proxel BZ	0.39
TOTAL	100.00

TABLE 9: ORANGE

Water	51.77
Polyurethane resin	35.00

Glycerin	9.00
FC-120	0.08
Hostafine Red HF3S	2.52
Hostafine Yellow Green	1.24
Proxel BZ	0.39
TOTAL	100.00

TABLE 10: YELLOW

Water	51.78
Polyurethane resin	35.00
Glycerin	9.00
FC-120	0.08
Hostafine Yellow Green	3.75
Proxel BZ	0.39
TOTAL	100.00

TABLE 11: BROWN

Water	51.73
Polyurethane resin	35.00
Glycerin	9.00
FC-120	0.08
Hostafine Rubine F6B	1.55
Hostafine Blue	0.24
Hostafine Yellow Hr	2.01
Proxel BZ	0.39
TOTAL	100.00

Suitable polyurethane resins are commercially available from Bayer Corp. The polyurethane resins provided by Bayer are sold under the name, DISPERCOLL. Three particular polyurethane resins which are suitable in the composition according to the present invention are Dispercoll U KA 8481, Dispercoll DC 53, and Dispercoll DC 54. These polyurethane resins may be used in the composition either alone, as the only polyurethane resin, or in combination with each other or other suitable polyurethane resins. The Dispercoll polyurethane resins already include water, and are provided commercially as a polyurethane dispersion having from 40 - 50% polyurethane. Thus, where a polyurethane dispersion, such as Dispercoll, is

used, the water content of the dispersion should be taken into account in determining overall water content of the composition. Of course, other suitable polyurethane resins would work in the present invention.

The Dispercoll polyurethane resins, as well as other preferred resins, possess certain physical properties. The tensile strength of preferred polyurethane resins ranges from 2000 - 5000 psi. The percent elongation of the preferred polyurethane resins ranges from 400 - 700%. The preferred polyurethane resins also demonstrate a modulus (at 100% elongation) of 300 - 500 psi. These physical properties and their meanings are well known to those skilled in the art. Of course, these polyurethanes exhibit the characteristics identified above as important to the erasability of the ink according to the present invention.

Exemplary pigments are available commercially under the name Hostafine from Hoechst Aktiengesellschaft. These particular pigments are provided in aqueous solution with propylene glycol and contain approximately 30 - 40% pigment. There are a variety of color pigments sold under the name Hostafine, and one skilled in the art can blend them, or any other suitable pigment, to obtain virtually any color desired. Pigment selection can also depend upon the intended delivery system, and one skilled in the art can select the appropriate pigment based on the known intended delivery.

Suitable surfactants, especially fluorosurfactants, are optionally present in the composition of the present invention to maintain flowability and good coverage of the surface to which the composition is applied. One suitable surfactant is sold under the name Fluorad by 3M. Fluorad FC-120

contains approximately 38% water. Of course, other suitable surfactants could also be used.

The composition of the present invention may also optionally include one or more anti-microbial preservatives. The anti-microbial preservative may be added to counter the formation or growth of fungi, bacterias, yeasts, or molds. Over time, these detrimental components can form in the composition, particularly in the case where the composition is present on a marker tip or some other nib that allows air to easily contact the composition. Exemplary anti-microbial preservatives would include Proxel, sold by Avecia, and Troysan, sold by Troy Chemical Company of New Jersey. Any suitable anti-microbial preservative could, of course, be used. When used, the preferred amount of anti-microbial preservative is from 0 - 0.5% by weight, and a more preferred amount is from 0.10 - 0.40% by weight.

The present invention also includes markers and other application instruments, such as ball point pens. Such application instruments which are used to apply the composition of the present invention would include an outer body having a first end, an applicator at the first end of the outer body, and a reservoir included within the outer body and in fluid communication with the applicator. The application instruments of the present invention would contain in their reservoirs a water-based, erasable marking composition in accordance with the present invention disclosed above.

The applicator itself could be any of a number of forms of known writing nibs, such as a ball or a piece of felt. The applicator could also include the nozzle of a sprayer or the bristles of a brush.

Although the present invention has been particularly described in conjunction with specific preferred embodiments, it is evident that many alternatives, modifications, and variations will be apparent to those skilled in the art. It is therefore contemplated that the appended claims will embrace any such alternatives, modifications, and variations as falling within the true scope and spirit of the present invention.